# Informações do estudo

Referência: Cakir (1)

Grandeza: Rugosidade

Tipo: Ra

Material: AISI P20

Ferramenta: CNMG 120408 1

Número de experimentos: 27

Observações:  
Workpiece: diameter of 70mm and a length of 300mm  
Lathe: 5.5kW

# Unidades

Velocidade: m/min

Avanço: mm/rev

Profundidade de corte: mm

Rugosidade: μm

# Dados de teste

|  |  |  |  |
| --- | --- | --- | --- |
| Rugosidade | n | f | a |
| 0.82 | 160.0 | 0.12 | 1.0 |
| 2.58 | 120.0 | 0.22 | 1.0 |
| 1.45 | 160.0 | 0.18 | 2.0 |
| 1.63 | 120.0 | 0.18 | 2.0 |
| 0.87 | 120.0 | 0.12 | 1.0 |
| 1.39 | 160.0 | 0.18 | 1.0 |

# Dados de treino

|  |  |  |  |
| --- | --- | --- | --- |
| Rugosidade | n | f | a |
| 2.09 | 160.0 | 0.22 | 2.0 |
| 1.43 | 200.0 | 0.18 | 2.0 |
| 1.93 | 200.0 | 0.22 | 1.5 |
| 1.97 | 200.0 | 0.22 | 2.0 |
| 1.63 | 120.0 | 0.18 | 1.5 |
| 0.78 | 200.0 | 0.12 | 1.5 |
| 1.37 | 200.0 | 0.18 | 1.5 |
| 2.63 | 120.0 | 0.22 | 2.0 |
| 2.58 | 120.0 | 0.22 | 1.5 |
| 1.1 | 120.0 | 0.12 | 2.0 |
| 0.87 | 160.0 | 0.12 | 2.0 |
| 0.86 | 200.0 | 0.12 | 2.0 |
| 1.77 | 200.0 | 0.22 | 1.0 |
| 1.28 | 200.0 | 0.18 | 1.0 |
| 1.09 | 120.0 | 0.12 | 1.5 |
| 2.03 | 160.0 | 0.22 | 1.5 |
| 0.86 | 160.0 | 0.12 | 1.5 |
| 0.77 | 200.0 | 0.12 | 1.0 |
| 2.0 | 160.0 | 0.22 | 1.0 |
| 1.62 | 120.0 | 0.18 | 1.0 |
| 1.42 | 160.0 | 0.18 | 1.5 |

# RN

Número de neurônios: 25

Taxa de aprendizado: 1.000000e-01

Número de épocas: 562

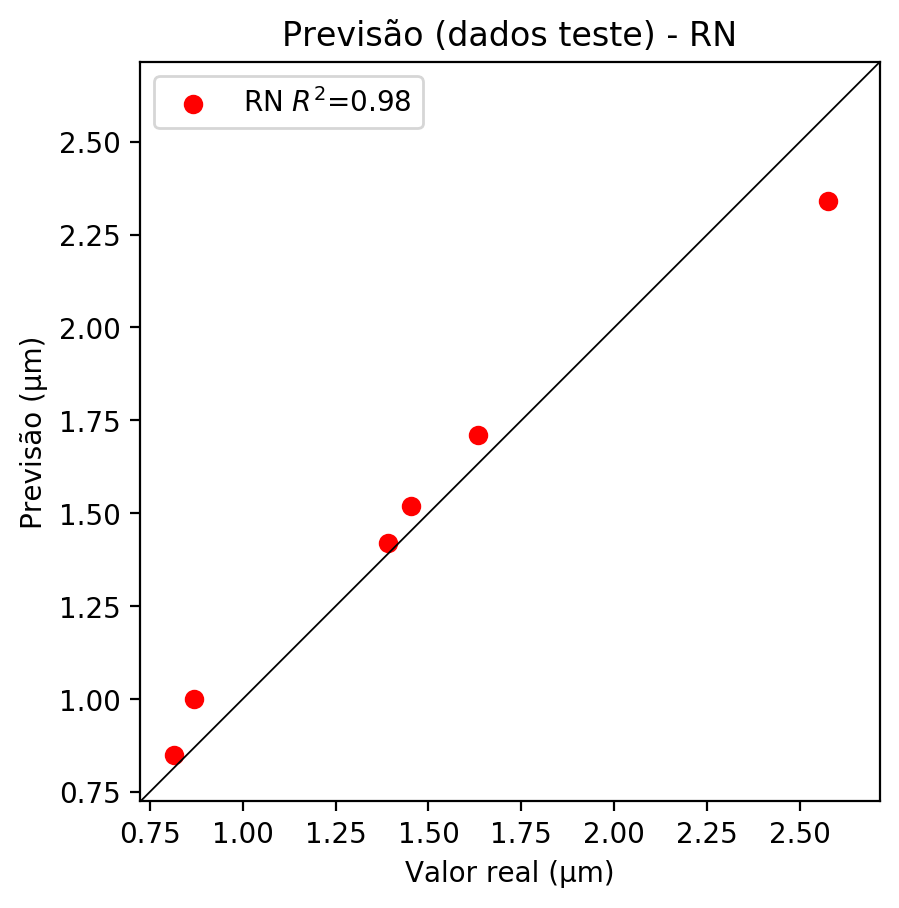
2° camada: True

Função de ativação: relu

# Erros

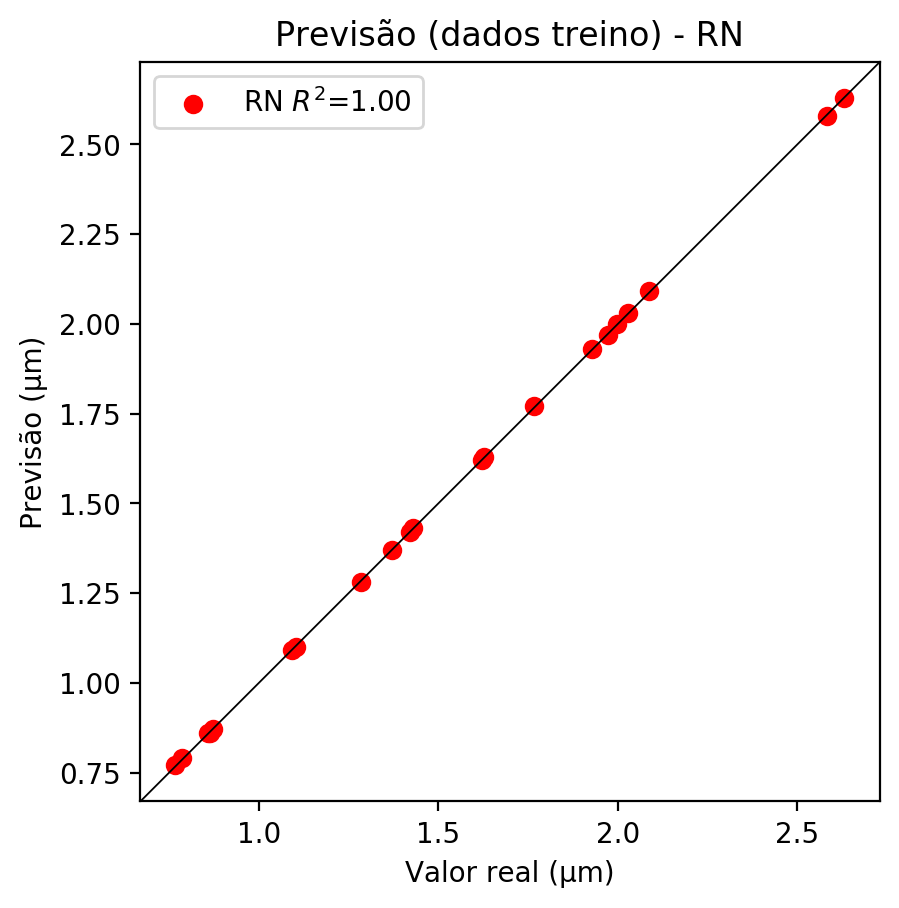
**Dados de teste**

* Erro relativo médio: 6.66
* Coeficiente de correlação: 0.99
* Coeficiente de determinação: 0.98
* MSE: 0.01
* RMSE: 0.1



**Dados de treino**

* Erro relativo médio: 0.19
* Coeficiente de correlação: 1.0
* Coeficiente de determinação: 1.0
* MSE: 0.0
* RMSE: 0.0



# Pesos

Pesos - camada oculta 1

[[-0.2784922 -0.0186557 -0.05803762 0.16786915 0.21155587 0.2580158  
 -0.21796186 0.15958515 0.13901283 -0.24818468 -0.23715976 -0.2889506  
 0.04153846 -0.15375406 -0.26605326 -0.20342515 0.4557472 -0.69504404  
 -0.1894847 -0.43592903 0.2026947 -0.85063803 0.48447326 -1.2402223  
 0.04642592]  
 [ 0.15396212 0.04136308 -0.02650652 -0.5764885 -1.2580888 0.03994693  
 0.2741468 0.13146822 -0.20003045 -0.13833258 1.7025974 -0.08706844  
 -0.13807264 0.25092292 -0.21578836 -0.27637503 -0.9416771 0.53351736  
 0.97058004 -0.11349934 -0.53555447 -0.81066996 -0.37184435 0.23713638  
 0.94832736]  
 [-0.5167954 0.20062268 -0.44531518 0.01052454 0.00709047 -0.20954143  
 0.26869464 0.13795725 0.09703629 0.38627493 0.5164158 0.01443109  
 -0.34128425 -0.21205229 -0.3224156 0.01202716 -0.13411334 -0.13469082  
 -0.32567024 -0.03930873 -0.08260667 0.15753055 -0.58611095 0.26618147  
 0.34005615]]

Bias - camada oculta

[-0.67340016 -0.38587356 -1.2206658 -0.6567874 0.39944872 -0.81829816  
 -0.6220067 -1.0244111 -0.8771305 -1.1697078 -0.04544879 -0.9961129  
 -0.22575502 -0.7581609 -0.76233554 -0.7169341 -0.39783815 -0.29253253  
 -0.32737616 -1.3572092 -0.12219576 -0.19962884 -0.35140195 -0.32424515  
 -0.19663313]

Pesos - camada oculta 2

[[-3.73656482e-01 -2.48875275e-01 3.61308277e-01 -4.37600553e-01  
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 -4.85628694e-01 5.41685045e-01 4.44569468e-01 4.52118933e-01  
 -1.02307999e+00 4.20970321e-01 3.08628350e-01 -3.05519193e-01  
 -3.10944885e-01 -3.58960003e-01 2.27229297e-01 -5.42591691e-01  
 2.72019804e-01]  
 [-1.06215157e-01 2.45423838e-01 -2.07953423e-01 8.53955895e-02  
 -1.79128930e-01 -5.61990440e-01 -1.57626081e+00 -2.62378931e-01  
 -1.67480946e-01 2.89614916e-01 -9.39205229e-01 3.46166082e-02  
 1.74155787e-01 -9.58344281e-01 -6.91025376e-01 -2.03986745e-02  
 8.42039660e-02 -3.09418738e-01 -2.85625845e-01 2.77445745e-02  
 2.51609609e-02 -6.05449677e-01 -8.22367132e-01 1.53216168e-01  
 -2.77342111e-01]  
 [ 8.52496505e-01 1.23714738e-01 1.12682080e+00 3.51282656e-01  
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 4.46409643e-01 3.22877586e-01 -3.22124571e-01 3.56917351e-01  
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 -1.07239139e+00]  
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 -3.58411521e-02 -4.21225995e-01 -9.60527778e-01 6.49504811e-02  
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 3.61646831e-01 -5.50661027e-01 -7.20920086e-01 2.40485474e-01  
 4.69101280e-01 -2.54334331e-01 -7.36023366e-01 -2.77024835e-01  
 -5.63902438e-01]  
 [ 8.50667134e-02 -3.60623926e-01 -3.70105714e-01 -2.82669872e-01  
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 -5.75512648e-01]]

Bias - camada oculta 2

[-0.81663173 0.02519181 0.1738363 -0.01659877 0.1565234 -0.28598922  
 -0.4290506 -1.2401569 -0.08212601 -1.1345506 -0.8045276 -0.7504744  
 -1.0346755 -0.2610196 -0.60053426 -0.21668652 -0.03418436 -0.6105851  
 -0.60053885 -0.5967174 -0.57651573 -0.6005454 -0.9148522 -0.13480839  
 -0.98121053]

Pesos - camada saída

[[-0.20741291 -0.06664593 -0.30431908 -0.10381562 0.33561087 0.2682646  
 0.06174326 -0.05693069 0.02908536 -0.38664597 0.42332336 -0.09835811  
 -0.34686604 -0.31478107 0.38519087 -0.02286611 0.27554128 0.47307178  
 0.1961311 -0.03860985 0.28462785 -0.2655308 -0.3288502 -0.06057562  
 -0.10150536]]

# Iterações

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Média | Desvio | n | ln | 2° camada | Função | Épocas |
| -0.0997 | 0.0882 | 10 | 0.1 | False | relu | 38 |
| -0.1158 | 0.1698 | 17 | 0.1 | True | relu | 716 |
| -0.127 | 0.1646 | 7 | 0.01 | True | tanh | 130 |
| -0.2578 | 0.2273 | 19 | 0.001 | False | tanh | 282 |
| -0.2 | 0.2031 | 29 | 0.001 | False | relu | 469 |
| -0.1119 | 0.1278 | 88 | 0.1 | False | tanh | 926 |
| -0.1254 | 0.1468 | 95 | 0.0001 | True | relu | 984 |
| -0.1065 | 0.1172 | 10 | 0.01 | True | tanh | 865 |
| -0.7323 | 0.5658 | 58 | 0.001 | True | relu | 8 |
| -0.1292 | 0.1816 | 9 | 0.01 | False | tanh | 514 |
| -0.1451 | 0.1375 | 73 | 0.0001 | True | relu | 729 |
| -0.169 | 0.2097 | 22 | 0.001 | True | relu | 543 |
| -0.0789 | 0.098 | 25 | 0.1 | True | relu | 562 |
| -0.1557 | 0.1648 | 53 | 0.001 | False | relu | 498 |
| -0.0829 | 0.0948 | 83 | 0.01 | True | relu | 337 |
| -0.4615 | 0.3472 | 99 | 0.01 | False | tanh | 16 |
| -0.1105 | 0.0969 | 23 | 0.01 | False | relu | 472 |
| -0.1492 | 0.1439 | 24 | 0.001 | True | relu | 778 |
| -0.1123 | 0.1473 | 58 | 0.01 | True | tanh | 382 |
| -0.2614 | 0.1798 | 35 | 0.1 | False | tanh | 596 |

# RL

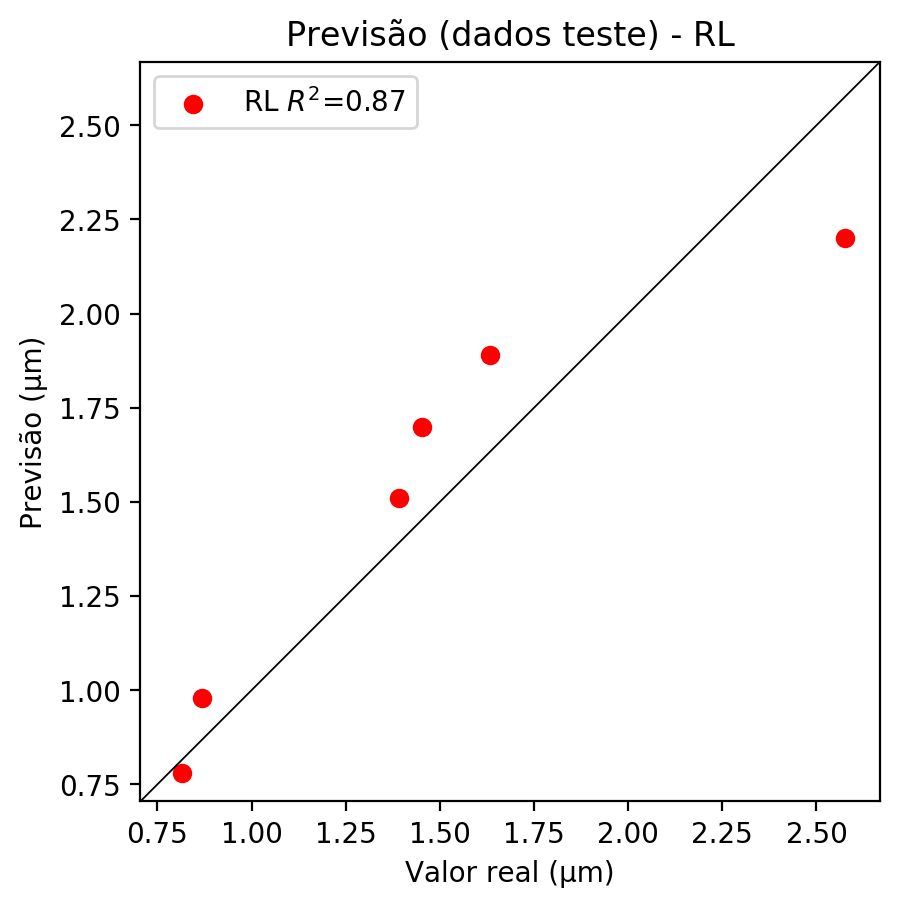
# Coeficientes

[ 0. -0.28755713 0.89061203 0.13175321]

# Erros

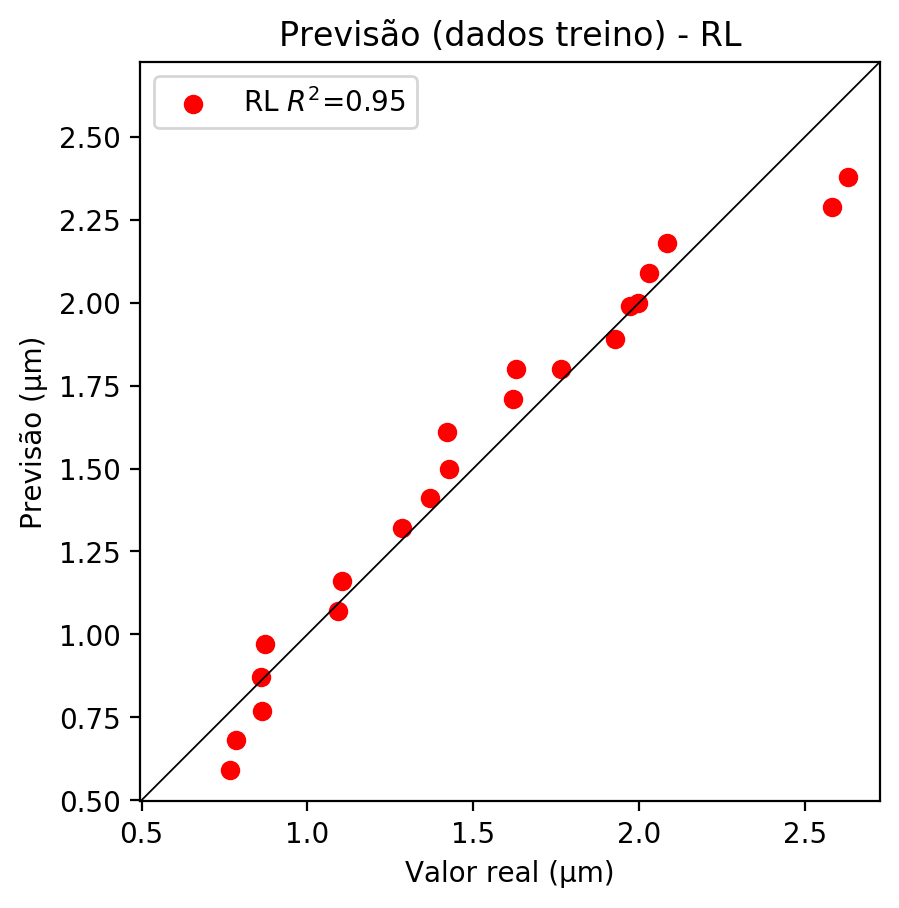
**Dados de teste**

* Erro relativo médio: 12.2
* Coeficiente de correlação: 0.93
* Coeficiente de determinação: 0.87
* MSE: 0.05
* RMSE: 0.22



**Dados de treino**

* Erro relativo médio: 6.67
* Coeficiente de correlação: 0.98
* Coeficiente de determinação: 0.95
* MSE: 0.01
* RMSE: 0.1



# RP2

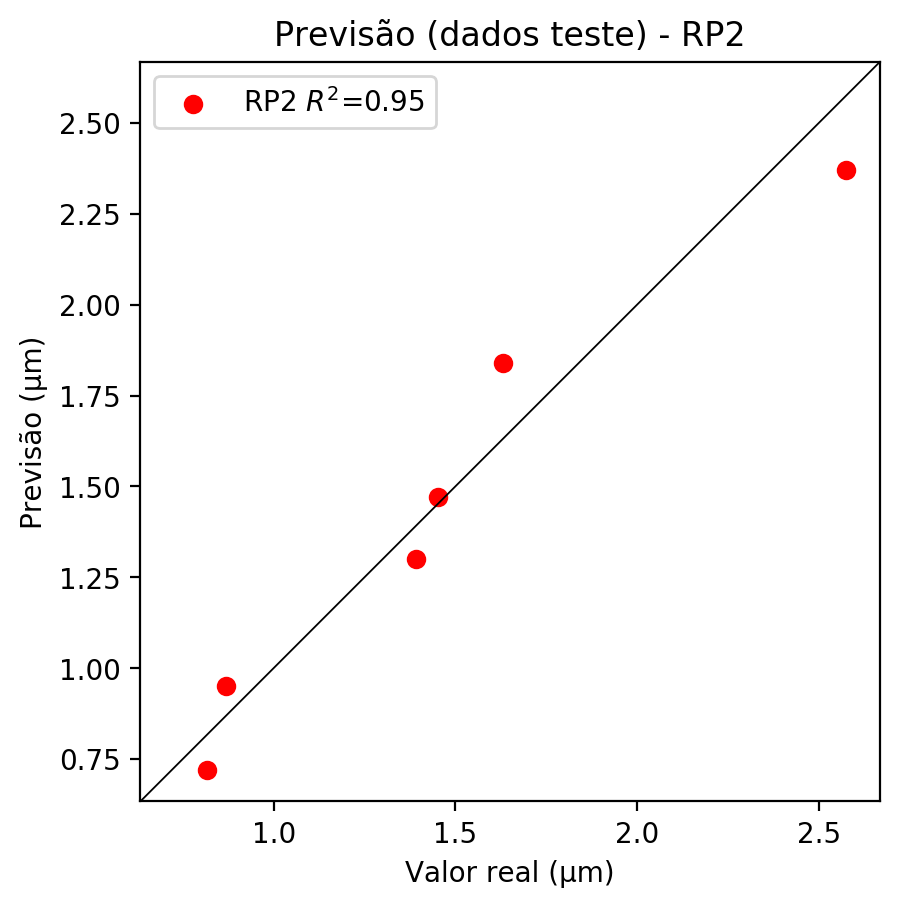
# Coeficientes

[ 0. -0.2940593 0.95449663 0.12008282 0.16400438 -0.11442409  
 -0.01867223 0.20634509 0.01580245 -0.02271492]

# Erros

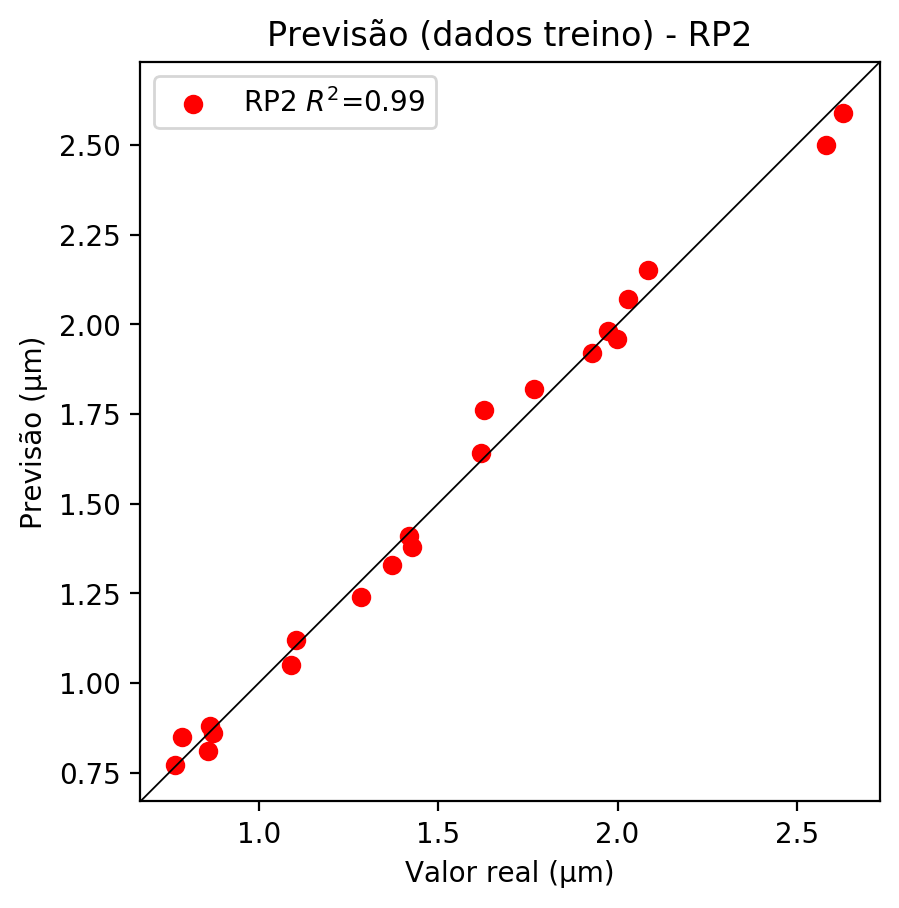
**Dados de teste**

* Erro relativo médio: 8.27
* Coeficiente de correlação: 0.97
* Coeficiente de determinação: 0.95
* MSE: 0.02
* RMSE: 0.14



**Dados de treino**

* Erro relativo médio: 2.78
* Coeficiente de correlação: 1.0
* Coeficiente de determinação: 0.99
* MSE: 0.0
* RMSE: 0.0



# RP3

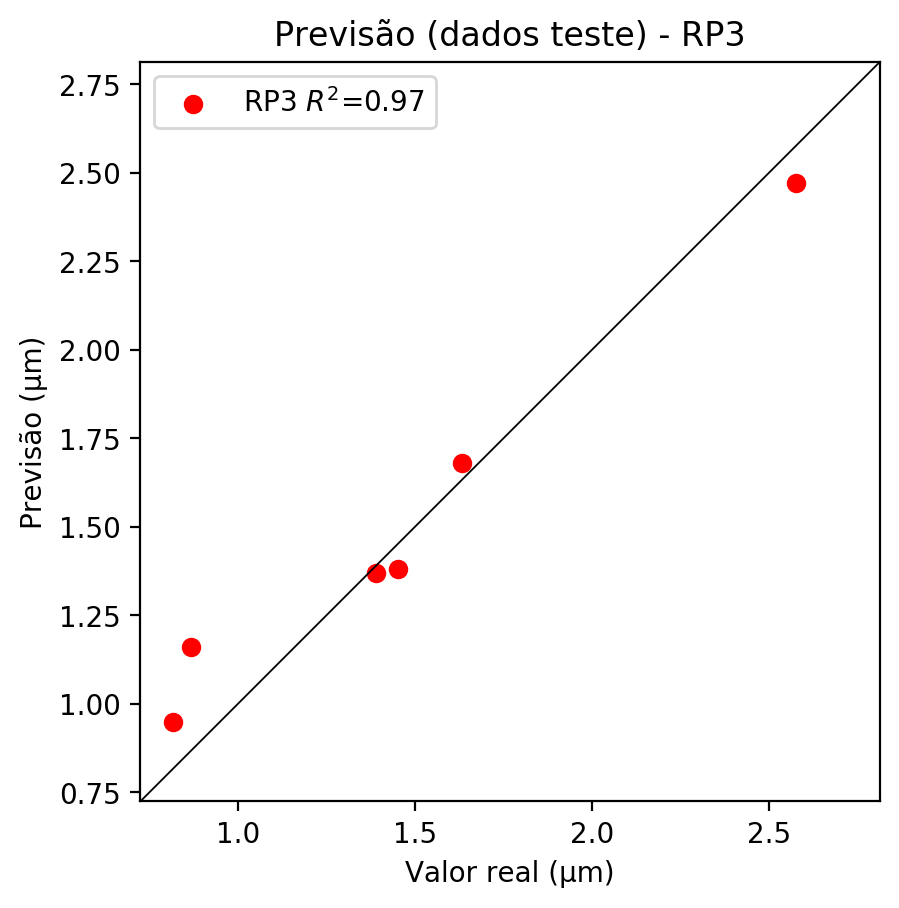
# Coeficientes

[ 0. -0.05477447 0.29605597 -0.00106707 0.1469083 -0.12898647  
 0.02858077 0.26461543 0.05139706 0.00177121 -0.07911868 0.05835757  
 0.04866592 -0.13007931 -0.01418403 -0.01299205 0.4276364 0.00760527  
 -0.03545217 -0.00154132]

# Erros

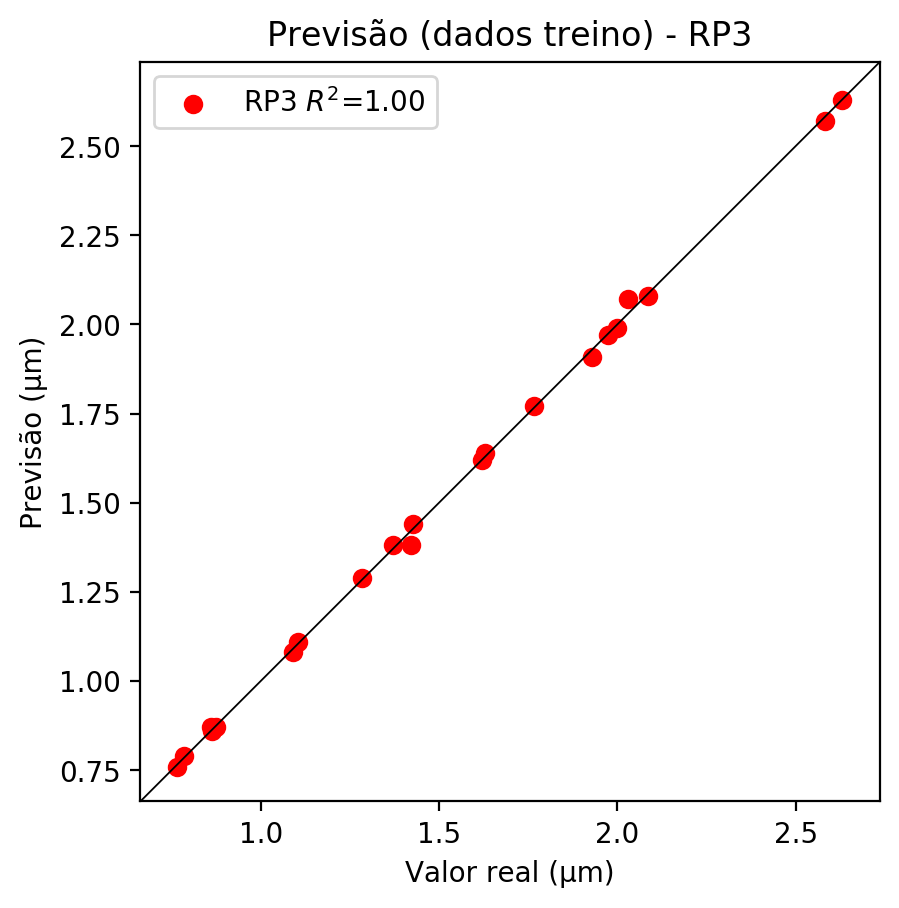
**Dados de teste**

* Erro relativo médio: 10.57
* Coeficiente de correlação: 0.98
* Coeficiente de determinação: 0.97
* MSE: 0.02
* RMSE: 0.14



**Dados de treino**

* Erro relativo médio: 0.72
* Coeficiente de correlação: 1.0
* Coeficiente de determinação: 1.0
* MSE: 0.0
* RMSE: 0.0



# RP4

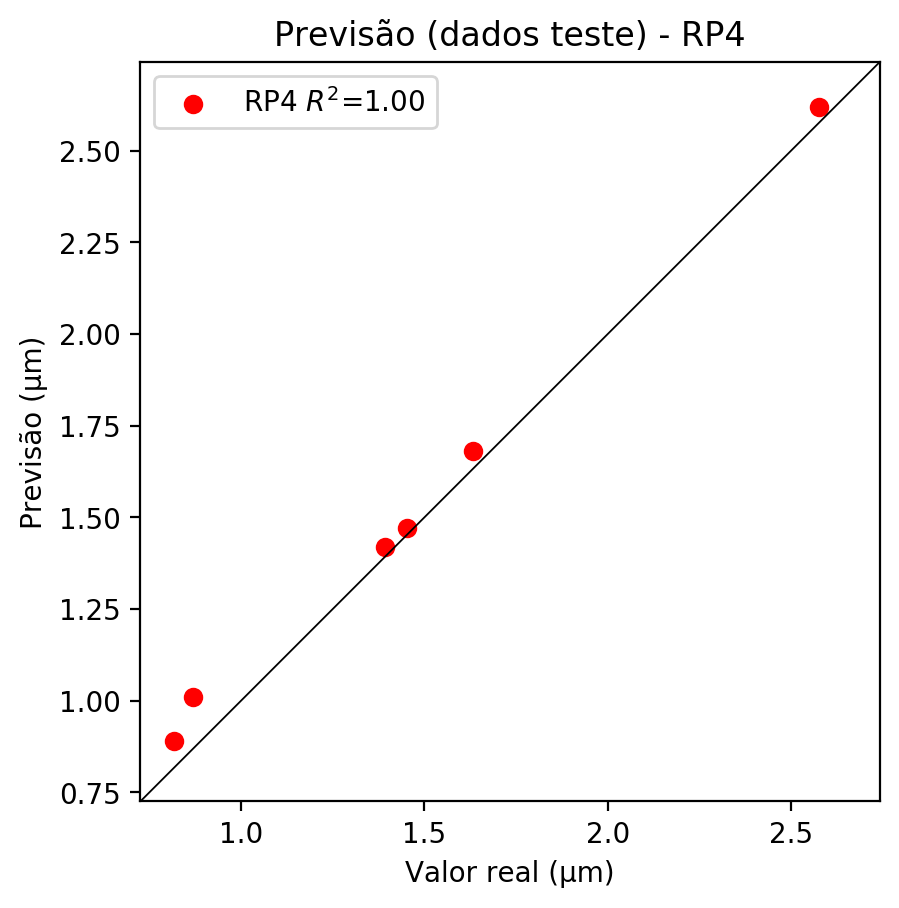
# Coeficientes

[ 0. -0.05483832 0.29096177 0.00908599 0.02599839 -0.02805783  
 0.004322 0.08902959 0.00671193 0.01022031 -0.0792109 0.08700993  
 0.03155253 -0.13647609 0.02453325 -0.01229931 0.42027811 0.00176868  
 -0.00565081 0.0131242 0.03755323 -0.04052798 0.00624289 0.0777048  
 -0.01831553 -0.01889178 -0.02813969 0.00709356 -0.03399945 0.00624289  
 0.06286841 0.00764243 -0.00768218 0.00969501 0.01476267]

# Erros

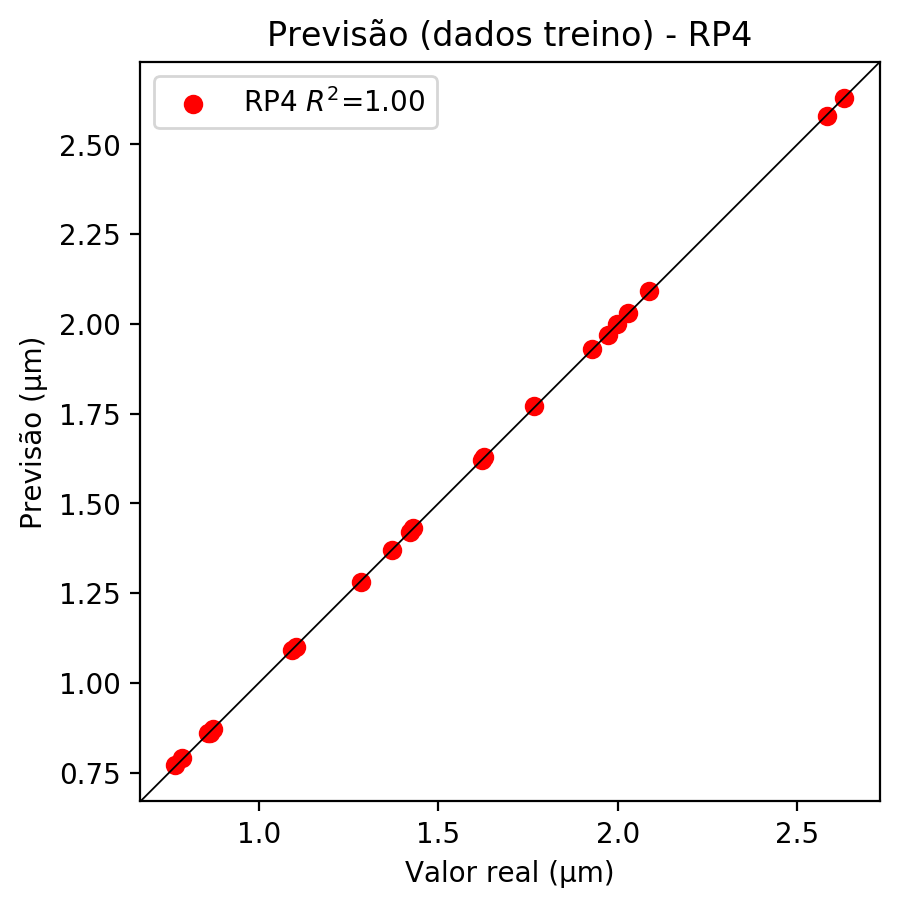
**Dados de teste**

* Erro relativo médio: 5.54
* Coeficiente de correlação: 1.0
* Coeficiente de determinação: 1.0
* MSE: 0.01
* RMSE: 0.1

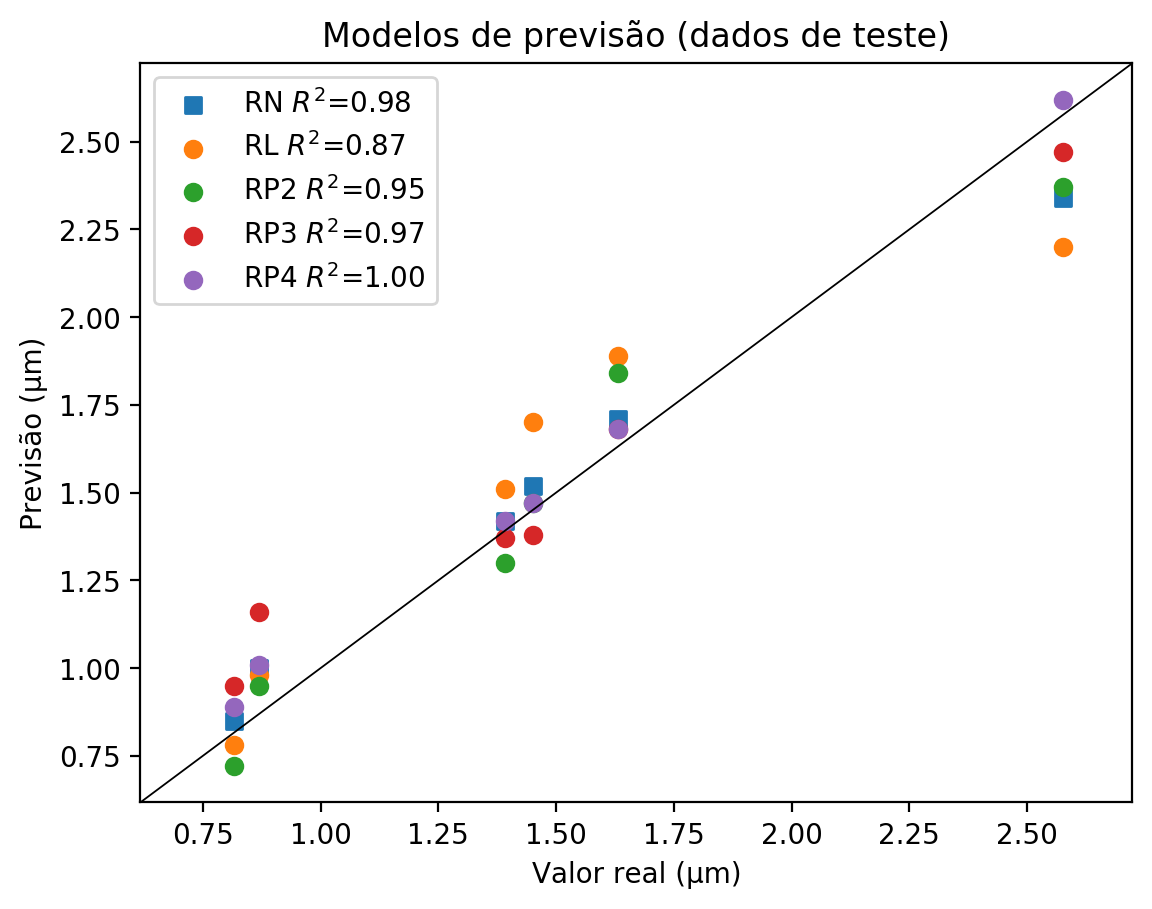


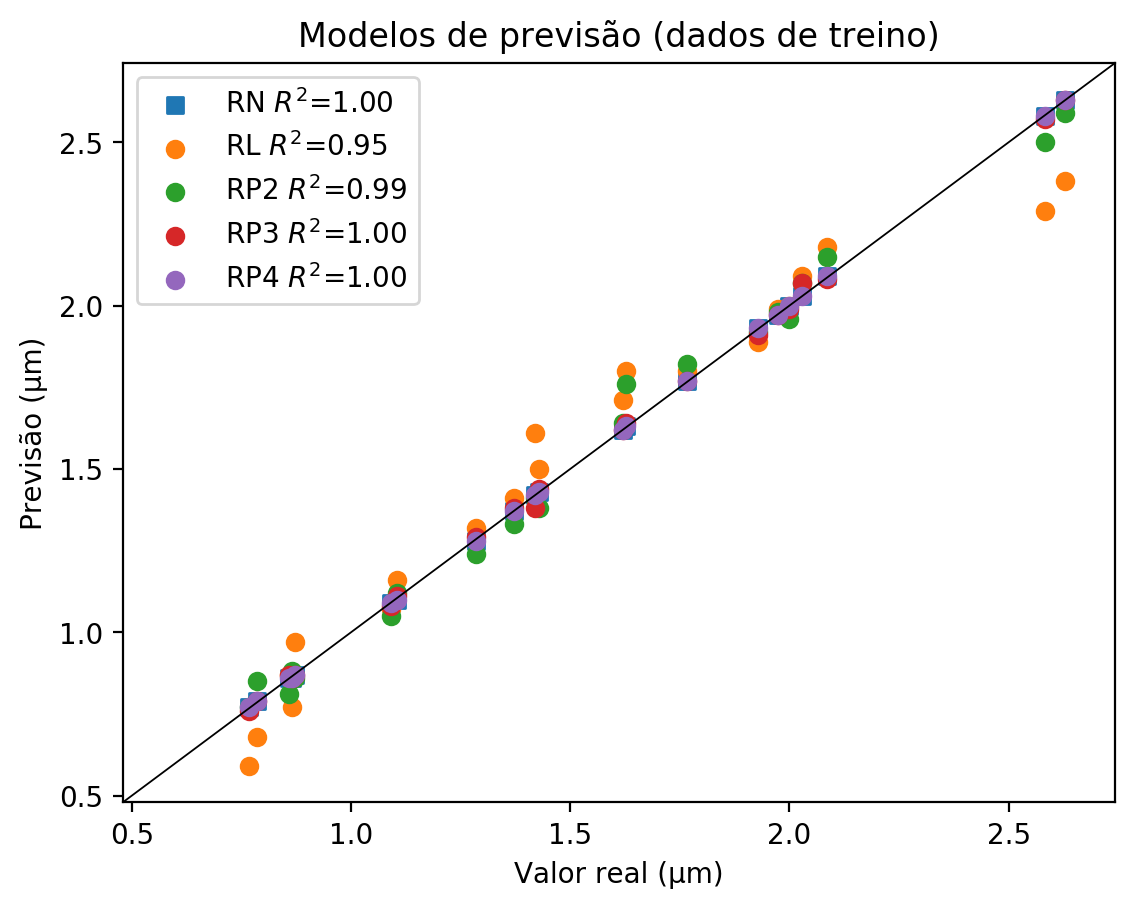
**Dados de treino**

* Erro relativo médio: 0.19
* Coeficiente de correlação: 1.0
* Coeficiente de determinação: 1.0
* MSE: 0.0
* RMSE: 0.0



# Geral





**Dados de teste**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Valor real | RN Previsto | RN Erro (%) | RL Previsto | RL Erro (%) | RP2 Previsto | RP2 Erro (%) | RP3 Previsto | RP3 Erro (%) | RP4 Previsto | RP4 Erro (%) |
| 0.82 | 0.85 | 4.17 | 0.78 | 4.41 | 0.72 | 11.76 | 0.95 | 16.42 | 0.89 | 9.07 |
| 2.58 | 2.34 | 9.16 | 2.2 | 14.6 | 2.37 | 8.0 | 2.47 | 4.11 | 2.62 | 1.71 |
| 1.45 | 1.52 | 4.68 | 1.7 | 17.08 | 1.47 | 1.24 | 1.38 | 4.96 | 1.47 | 1.24 |
| 1.63 | 1.71 | 4.78 | 1.89 | 15.81 | 1.84 | 12.75 | 1.68 | 2.94 | 1.68 | 2.94 |
| 0.87 | 1.0 | 15.07 | 0.98 | 12.77 | 0.95 | 9.32 | 1.16 | 33.49 | 1.01 | 16.23 |
| 1.39 | 1.42 | 2.08 | 1.51 | 8.55 | 1.3 | 6.54 | 1.37 | 1.51 | 1.42 | 2.08 |

**Dados de treino**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Valor real | RN Previsto | RN Erro (%) | RL Previsto | RL Erro (%) | RP2 Previsto | RP2 Erro (%) | RP3 Previsto | RP3 Erro (%) | RP4 Previsto | RP4 Erro (%) |
| 2.09 | 2.09 | 0.19 | 2.18 | 4.51 | 2.15 | 3.07 | 2.08 | 0.29 | 2.09 | 0.19 |
| 1.43 | 1.43 | 0.14 | 1.5 | 5.04 | 1.38 | 3.36 | 1.44 | 0.84 | 1.43 | 0.14 |
| 1.93 | 1.93 | 0.05 | 1.89 | 2.02 | 1.92 | 0.47 | 1.91 | 0.98 | 1.93 | 0.05 |
| 1.97 | 1.97 | 0.15 | 1.99 | 0.86 | 1.98 | 0.35 | 1.97 | 0.15 | 1.97 | 0.15 |
| 1.63 | 1.63 | 0.12 | 1.8 | 10.57 | 1.76 | 8.11 | 1.64 | 0.74 | 1.63 | 0.12 |
| 0.78 | 0.79 | 0.64 | 0.68 | 13.38 | 0.85 | 8.28 | 0.79 | 0.64 | 0.79 | 0.64 |
| 1.37 | 1.37 | 0.07 | 1.41 | 2.84 | 1.33 | 2.99 | 1.38 | 0.66 | 1.37 | 0.07 |
| 2.63 | 2.63 | 0.04 | 2.38 | 9.47 | 2.59 | 1.48 | 2.63 | 0.04 | 2.63 | 0.04 |
| 2.58 | 2.58 | 0.08 | 2.29 | 11.31 | 2.5 | 3.18 | 2.57 | 0.46 | 2.58 | 0.08 |
| 1.1 | 1.1 | 0.36 | 1.16 | 5.07 | 1.12 | 1.45 | 1.11 | 0.54 | 1.1 | 0.36 |
| 0.87 | 0.87 | 0.34 | 0.97 | 11.11 | 0.86 | 1.49 | 0.87 | 0.34 | 0.87 | 0.34 |
| 0.86 | 0.86 | 0.46 | 0.77 | 10.88 | 0.88 | 1.85 | 0.86 | 0.46 | 0.86 | 0.46 |
| 1.77 | 1.77 | 0.23 | 1.8 | 1.93 | 1.82 | 3.06 | 1.77 | 0.23 | 1.77 | 0.23 |
| 1.28 | 1.28 | 0.31 | 1.32 | 2.8 | 1.24 | 3.43 | 1.29 | 0.47 | 1.28 | 0.31 |
| 1.09 | 1.09 | 0.09 | 1.07 | 1.92 | 1.05 | 3.76 | 1.08 | 1.01 | 1.09 | 0.09 |
| 2.03 | 2.03 | 0.05 | 2.09 | 3.01 | 2.07 | 2.02 | 2.07 | 2.02 | 2.03 | 0.05 |
| 0.86 | 0.86 | 0.12 | 0.87 | 1.28 | 0.81 | 5.7 | 0.87 | 1.28 | 0.86 | 0.12 |
| 0.77 | 0.77 | 0.52 | 0.59 | 22.98 | 0.77 | 0.52 | 0.76 | 0.78 | 0.77 | 0.52 |
| 2.0 | 2.0 | 0.1 | 2.0 | 0.1 | 1.96 | 1.9 | 1.99 | 0.4 | 2.0 | 0.1 |
| 1.62 | 1.62 | 0.0 | 1.71 | 5.56 | 1.64 | 1.23 | 1.62 | 0.0 | 1.62 | 0.0 |
| 1.42 | 1.42 | 0.0 | 1.61 | 13.38 | 1.41 | 0.7 | 1.38 | 2.82 | 1.42 | 0.0 |